

The g Factor of Lithiumlike Silicon $^{28}\text{Si}^{11+}$

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The relativistic electron-electron interaction can be stringently tested by high-precision measurements of the gyro-magnetic factor (g factor) of the valence electron bound in many-electron systems. Especially three-electron ions allow for a highly-sensitive test since they can be theoretically predicted to a high accuracy. To this end the g factor of the $2s$ valence electron bound in lithiumlike silicon $^{28}\text{Si}^{11+}$ has been determined with an uncertainty of $\delta g/g = 1.1 \cdot 10^{-9}$ [1], which is the most precise g factor measurement of a three electron system to date.

The g factor measurement

For the g factor measurement a single ion was stored in a cryogenic triple Penning trap setup for several months [2]. To determine the g factor via

$$g = 2 \frac{\nu_L}{\nu_c} \frac{q}{M_{ion}} \frac{m_e}{e} \quad (1)$$

the Larmor frequency ν_L and the free cyclotron frequency ν_c of the ion have to be measured, while the mass of electron m_e and ion M_{ion} are known from other high-precision experiments. The free cyclotron frequency can

close to the expected Larmor frequency are irradiated into the trap to induce spin flips. To determine the spin orientation with the continuous Stern-Gerlach effect, the ion is transported to a second Penning trap, where a magnetic inhomogeneity couples the spin orientation to the axial motion. Comparing the spin orientation to the orientation determined in the last cycle reveals if a spin flip was successfully induced. After several hundred cycles the spin flip probability as a function of the measured frequency ratio $\Gamma = \nu_L/\nu_c$ yields a g factor resonance as shown in Fig. 1.

We have recorded three resonances with different microwave powers to check for related systematic shifts. The experimental result $g_{\text{exp}} = 2.000\,889\,889\,9(21)$ is in excellent agreement with the theoretical value $g_{\text{exp}} = 2.000\,889\,909(51)$. The comparison between experimental and theoretical g factor confirms the many-electron contribution on the level of 10^{-4} , which is the most stringent test of relativistic many-electron calculations to date. Since the experimental value is by more than one order of magnitude more precise than the theoretical value, any improvement of the theoretical g factor will immediately improve this test.

Outlook

For highly sensitive tests of quantum electrodynamics with heavy ions the achievable theoretical precision is limited by unknown nuclear parameters. A measurement of both lithium- and hydrogenlike ions allows to cancel the contributions of the nuclear parameters to a large extent, hereby significantly increasing the stringency of the test [3]. Moreover, if combined with a measurement of the boronlike charge state, the fine structure constant α can be determined with a comparable uncertainty as the current value [4].

Having finished the g factor measurement of lithiumlike silicon, a g factor measurement of hydrogenlike carbon was started, aiming for an improvement of the precision of the electron mass by one order of magnitude.

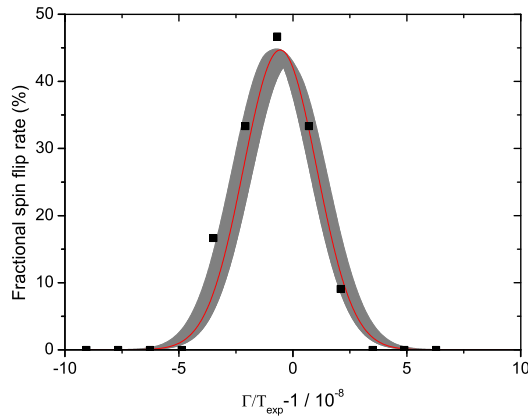


Figure 1: g -factor resonance of a single $^{28}\text{Si}^{11+}$ -ion.

be determined by measuring the three eigenfrequencies of the ion in a first Penning trap. Simultaneously, microwaves

* Work supported by Helmholtz Alliance HA216/EMMI, Max Planck Society and EU (ERC Grant No. 290870-MEFUCO).

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